7 Using Digital Resources for Learning in a Learning Activity

Learning Outcomes:

- Describe what is a Learning Design;
- Discuss a concept of a human activity in general, and a learning activity more specifically;
- Discuss a concept of tool mediation in a learning activity;
- Identify and select digital resources for learning that can serve as tools in a learning activity; and
- Develop and implement a learning design based on the RASE framework.

7.1 An Idea of a Learning Design

So far, we have discussed different forms of digital resources for learning including: information displays, presentation resources, practice resources, conceptual representations, and data display resources. How can these digital resources for learning be used in the most effective way in teaching? In this chapter, we will explore some theoretical issues and practical aspects of the design of educational activities for the utility of digital resources for learning.

Important
Teaching suitably for today and the future enables learners to construct knowledge for themselves, learn, not just information and procedures, but

D. Churchill, *Digital Resources for Learning*, Springer Texts in Education,
DOI 10.1007/978-981-10-3776-4_7

also develop deep conceptual knowledge that supports theoretical thinking and develop new literacies.

As readers might notice, in this book, the author argues that traditional education practices need to change in order for teaching to be appropriate, given the developments and the needs of the contemporary world. Teaching suitably for today and the future is what enables learners to construct knowledge for themselves; to learn, not just information and procedures, but also develop deep conceptual knowledge that supports theoretical thinking[1]; and in addition to disciplinary content, learn and develop competencies, mindsets and new literacies for living, working, socializing and learning in the modern world. Such teaching, we argue, is learning-centred, rather than traditionally teacher-centred, or even student-centred. A student-centred idea is a way to move teaching practices away from traditional approaches, however, we need to step ahead beyond this, towards the one that gives full recognition to aspects of relevant learning theories, understanding of how humans learn, and how human knowledge is used in application and innovation. A teacher's role in such teaching is to design learning experiences for learners, and this plan for the achievement of learning outcomes we call a *learning design* (Churchill et al. 2013). A learning design is a plan for the engagement of learners in a learning-centred activity where they use resources and work on projects, research, design and explore solutions to problems, and pursue innovations. The foundation of a learner's knowledge are those conceptual forms which learners develop for themselves through learning-centred activities and the use of resources, test through applications, used as a base to construct further knowledge and create innovation. These conceptual forms have personal and socio-cultural history, and are developing along the trajectory of knowledge humanity that has disciplines up to the current stage. In other words, these are resources developed within our culture to mediate our disciplinary and cross-disciplinary activities. These aid our intellectual activities, that is, enable us to engage in theoretical thinking in a way that, for example, a contemporary scientist, an engineer, a medical doctor, an economist or a mathematician does. Conceptual representations might be one of the most important digital resources for learning in this context. However, although certain digital learning resources originated based on a traditional idea of transmission of information from a resource to passive learners (e.g., presentation resources), these still have potential for use in effective learning designs and support the development of conceptual knowledge, in addition to being declarative and procedural.

[1]Theoretical thinking refers to "the development of deep structural strategies, the children's growing understanding of basic features and relationships laying not at the surface of the learning material, but demanding abstraction from the phenomenon and penetrating into the substance" (Hedegaard and Lompscher 1999, p. 13).

Before we continue a discussion about how to develop a learning design and use of digital resources for learning in that context, we will examine some key theoretical assumptions and ideas. These relate to a concept of a learning design to the following: (a) a human activity in general; (b) a learning activity as a specific form of a human activity; and (c) digital resources as mediating tools used in learning activities.

7.2 A Concept of a Human Activity

Teaching and learning are separate, but connected forms of human activities. Engeström (1987) articulated a general representational framework of any human activity (see Fig. 7.1). An activity can be as small as making a cup of tea, or as large as national education. According to this framework, a subject in an activity transforms an object into an outcome. For example, a builder transforms bricks, mortar, wood material, roof tiles, armature, etc., into a house. As a human acts on nature to transform it, and in order to deal with challenges and reach an outcome, he or she deploys various tools. An outcome, in our example of a builder, is the final house being sold and profit to be made from it, while tools are, for example, a blue print, reference documents, Construction Calculator App, a mortar mixer, measuring instruments, a wheelbarrow, a saw, a hammer, a power drill, a trowel, a brick jointer, a plumb and a chalk line.

Important
In an activity, learners learn from an experience by receiving feedback from the environment they are acting upon.

In an activity, a subject and an object are in a relationship where "… the subject is transforming the object, while the properties of the object penetrate into the subject and transform him or her" (Kutti 1997, p. 32). In other words, a subject learns from an experience by receiving feedback from the environment he is acting upon. This process is mediated by tools (or supporting artefacts and resources) whose properties

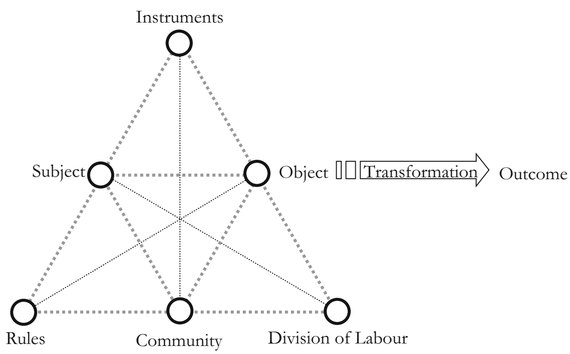

Fig. 7.1 A representational framework of an activity (modified from Engeström 1987)

and uses might also penetrate into a subject and transform him or her. For example, a number of studies have investigated how the integration of technology in teaching lead to the transformation of teachers and their pedagogical practices (e.g., Hardman 2005; Glover et al. 2015; Murphy and Manzanares 2008; Peruski and Mishra 2004). Often, a subject in an activity collaborates, and is not an "…unaided individual divorced from a social group and from supporting artifacts" (Nardi 1997, p. 67). When an activity involves collaboration amongst multiple individuals, there is always a division of labour. In addition, an activity is carried out according to certain rules, standards, requirements and framing parameters. Tools, community, division of labour and rules, are both enabling and constraining meaning that these all mediate goal-directed actions that can be executed within an activity.

For example, school education is one large and complex activity system with a community composed of teachers, principals and deputies, administrative staff, councillors, heads of departments, laboratory technicians, etc., all working together on transforming objects of their activity (learners) into an outcome (school graduate). All these members of the community execute different actions essential in completing this transformation (e.g., someone teaches mathematics, someone social science, while someone takes care of learner administration). Within this community, there is a division of labour (for example, principal and teachers do different things and have different powers) and there are rules (e.g., curriculum and assessment requirements). Often, *contradictions* arise in an activity between different nodes (e.g., subject and rules, or community and division of labour), and these contradictions cause changes in the activity itself (see Lim 2002; Murphy and Manzanares 2008). Contradictions might emerge with other activities that in some way relate or affect the current activity (e.g., a tool making activity). Thus, human activities, in general, are usually under continuous change.

7.3 A Learning Activity and a Learning Design

Learning activity is a specific kind of human activity (see Davydov 1999). It is unique in that it is characterized by voluntary learning—a subject of the activity is a learner, its motive is learning, and the object is the material to be learnt (or 'appropriated' in Davidov's term) through transformation into an outcome. For Hedegaard and Lompscher (1999), learning activity is "directed towards the acquisition of societal knowledge and skills through their individual re-production by means of special actions upon *learning objects*" (p. 12).

Relevant literature suggests that an outcome of a learner's activity should be the development of '*theoretical thinking*' (Chaiklin 1999; Davydov 1999; Hedegaard and Lompscher 1999). Theoretical thinking is important for learners because "development of creative abilities, initiatives, self-understanding, and, finally, the development of their personality depend on it" (Davydov 1999, p. 132). The development of theoretical thinking is achieved through activities "related to the conceptual foundations of the subject matter being taught, which in turn are related to the societal traditions within which this knowledge was originally developed" (Chaiklin 1999, p. 189). For Davydov (1999), to design an activity which supports the development of theoretical thinking "one needs to use such material that the children could perform the respective transformations and make object-related or mental experiments with the material" (p. 128). Furthermore, Davydov (1999) suggests that, often, learning does not occur because "textbooks and methodical recommendations for the instruction of particular school subjects do not meet the requirement of the very learning material and the intended way of how to introduce the subject into the teaching/learning process" (p. 130). Hence, as Chaiklin (1999) suggests, in order to realize the development of theoretical thinking "the key is to have a significantly good analysis of the subject matter, such that one can create a *framework of learning task* within which variations in pupil motives and motivation can find expression" (p. 188).

A motive for a subject (a learner) in a learning activity is to achieve learning outcomes specified by a curriculum, or perhaps, to achieve a high grade in exams (an outcome). However, in practice, how many learners are motivated to learn? This represents one of the key challenges for educators—how to motivate learners, and how to sustain that motivation and engagement throughout learning. What might be a solution to this problem? How to design activities that are engaging and sustain the motivation of learners?

In many human activities other than a learning activity, learning emerges as a special component of this experience (i.e., learning is incidental). For Engeström (1987), learning might occur in the context of at least three kinds of activities other than a learning activity: work, science and art. Learning outcomes per se are not a motive behind these activities—rather, a motive may be, for example, to answer an interesting inquiry (science), design computer graphics (art), or make money for living (work). Engeström (1987) illustrates this by using an example where a child is allowed to go outside and play once he completed his homework. In this case, a motive for an activity and learning is play, not learning.

As it is a challenge for teachers to create learning activities where learners are motivated to learn, a strategy we call here '*masking*' is proposed as a solution. It means that we can design activities that on the surface are not learning activities, but are designed with an intention to result in learning, such as projects, problem solving and inquiries. These activities are learning-centred from the point of intention of their designers (teachers). Such activities make it possible for learners to learn with tools they use while transforming objects (materials) into an outcome (artefact), as well, from the development of an outcome. Often, in such a learning design, learners as subjects of an activity create learning artefacts (outcome of an activity) in formats such as (see Jonassen and Rohrer-Murphy 1999):

- *Physical artefacts*—e.g., a robot or a cardboard model;
- *Soft artefacts*—e.g., a computer-based model or a multimedia presentation; and
- *Cognitive artefacts*—e.g., a solution to a problem, or an idea or a theory based on inquiry.

In these activities, educational resources (including digital resources for learning) are tools, rather than material to be transformed into an outcome (as would be the case in a learning activity), that is, the use of tools and transformation lead to incidental learning. A plan for executing such an activity we refer to as 'a learning design'. From a teachers' perspective, these activities remain to be teaching activities, that is, a teacher is a subject of activity, a learning design is his or her tool, and he or she transforms an object (learners' knowledge) into an outcome (achievement of a learning outcome). Therefore, teaching, in this context, is learning-centred. So, when we talk about a learning design, we think of a plan developed by a teacher to serve as a tool in his/her teaching activity on one side, and on the other, from a learners' perspective, a framework for an activity where learners are engaged and motivated to participate. A learning design can be implemented in various environments, inside or outside of a class, online, blended mode, MOOC (Massive open online course), and even as a self-learning module.

Important
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Here is one example that illustrates a learning design. School learners in their mathematics and history class (cross-disciplinary engagement) are engaged in an activity to create models of Egyptian pyramids in Giza near Cairo. Three groups of learners in a class create one of the three different pyramids at that site: Menkaure, Khafre and Khufu pyramids. The fourth group of learners prepare a model of a terrain at Giza where these three models of pyramids once constructed are to be positioned. The fifth group of learners are "Khufu Pharaoh's advisors" who must select and illustrate a set of objects that the pharaoh will take into a pyramid for the 'afterlife'. This group will also prepare a hieroglyphic message of Pharaoh's legacy upon his death. Each group will have to create a small display board with an explanation/illustration of their artefact. This board will be placed on the final model of the site at Giza. The groups will then present their experiences and the final artefact to other classes, and showcase it during the school's open house day.

Each of the groups works on its own part of this project. This activity structure creates a community whose groups and members have specific roles and tasks (division of labor). The groups' tasks are mediated by certain rules that exist. Some rules are integral to their tasks, e.g., a model of a pyramid should show a cross section allowing an inner view. Rules might be imposed by other activities, e.g., pyramids must be designed according to a scaled measurement imposed by the size of the final site where they will be displayed or, objects that Pharaoh might take with him are subject to the size and capacity of a pyramid.

A variety of resources is used in these activities. Most of the learning occurs through the use and application of these resources, as well as through social engagement, decisions and action taken with others. Some are digital learning resources from websites (e.g., http://www.pbs.org/wgbh/nova/pyramid/) where learners explore information about ancient Egyptian culture and history (an information display resource or a presentation resource, depending on its design); a satellite image of Giza from Google Earth (an information resource); interactive resources allowing the exploration of rules which exist in similar triangles (a concept representation resource); a calculator used to calculate scaled-down measurements; or a mathematics e-book used as reference in relation to the construction of polyhedral objects (a presentation resource). Some tools are technical, such as scissors and drawing instruments. Technology-based tools might also be used to create a virtual model to be used as references for the creation of physical models (e.g., Google SketchUp).

What is a motive for learners to participate in this project? They might be motivated to participate because of a particular purpose, e.g., to participate in an inter-schools competition and win, or to provide a useful model for a local travel agency to brief potential tourist travellers about pyramids in Egypt and, in this way, acquire a donation for the school's sport club from the agency, or simply because the activity gives them play time. However, aligning any outcome with the motive of each member of a group is always difficult to achieve. This is something that teachers need to monitor during such kinds of activities. For Kutti (1997), an object and a motive themselves undergo changes through an activity and they might only reveal themselves in the process of doing. A teacher might deploy a variety of supporting strategies to deal with this challenge.

For us in this book, we see theoretical thinking in a discipline to be strongly related and dependent upon conceptual knowledge. Accordingly, we place emphasis on the usefulness of conceptual representations resources, as representations of disciplinary conceptual tools, and a special form of interactive and visual digital resources for learning. Technology opens the opportunity for design, development and delivery of interactive visual material for the effective manipulation and exploration by learners engaged in an activity which results in the development of conceptual knowledge required for theoretical thinking. We concur with Chaiklin (1999) that deep subject matter analysis is essential for learning design and the design of tools that would permit this to happen. This kind of analysis demands good subject matter expertize and understanding of the ways in which kernels of a subject matter evolved historically, and how learners can reproduce through an activity this knowledge and experience. We hope that our classification of digital learning resources will contribute to be a resolution of this problem. However, importantly, we do not see digital resources as learning objects of a learning activity. Rather, we see these as tools prescribed by a learning design which the learner uses during their activity. In this context, we would like to emphasize some important ideas about tools and how these connect to learning.

Important

Deep subject matter analysis is essential for learning design and of digital resources for learning. Digital resources are not objects of a learning activity. Rather, these are tools prescribed by learning design which learners use during their activity.

7.4 Learning Resources and Tool Mediation

Humans have developed and used tools throughout history to extend their own intellectual and physical capabilities. These tools are 'crystallized' social experience and cultural knowledge developed through human history (Kaptelinin 1997; Kutti 1997). Human activities, in general, include the conscious use of tools, and are outcome directed. In their mediating role, tools create connections between humans and the world (Nardi 1997). For Jonassen (1978), some "species of animals have discovered tools, but have been unable to conceive needs to construct tools or incorporate tools into their culture" in a way that humans do, because humans are conscious and motivated organisms which construct their subjectivity while adjusting to, and acting upon, their objective world. Tools enable us to carry on with otherwise impossible activities, e.g., flying, cutting through metal or viewing and manipulating micro-biological organisms, Nano-materials and DNA. Tools also amplify our intellectual capacity and make it possible to carry on with activities that are beyond our cognitive abilities, that is, tools mediate and extend our thinking. Engerström (1991, in Kutti 1997) writes that "… humans can control their own behavior—not 'from the inside', on the basis of biological urges, but 'from the outside' using and creating artifacts" (p. 12). For Kaptelinin (1997), tool mediation leads to "…the formation of 'functional organ,' the combination of natural human abilities with the capacities of external components—tools—to perform a new function or to perform an existing one more efficiently" (p. 109). Therefore, the use of tools "… shapes the way people act and, through the process of internalization, greatly influence the nature of mental development" (Kaptelinin 1997, p. 109). Kutti (1997) divides tools into material/physical tools and tools for thinking, while for Kaptelinin, tools are "external (like hammer or scissors) and internal (like concepts and heuristics)" (p. 109). Tool use leads to "mastery" (Zinchenko 1986, in Nardi 1997) and "internalization" (Leont'ev 1978; Vygotsky 1978) of features of these tools into ones knowledge and cognition. For Vygotsky (1978), tools are not only the means for manipulating reality, but they are also mediators of human cognitive functioning. We can think of tools as physical, but also digital, and conceptual resources (or a combination of these).

Now, if we consider that learning occurs in an activity (incidentally or directly), then resources used in that activity are mediating tools. It applies to digital resources for learning as well. Overall, a subject is using tools to transform an object of an activity and, at the same time, properties of the tool penetrate into the subject's cognition and transform his or her psychological activity. So, a tool can be an internal conceptual resource we use in thinking and making decisions about action upon an object of an activity. In the absence of internal conceptual resources, such tools can be supplied from outside and, in the case of this book, as digital resources for learning. In this sense, a tool is directed at internal cognitive, and indirectly at a physical activity in the world.

Learning is a phenomenon that qualitatively and quantitatively increases an individual's intellectual capability through the gradual interiorization of external experiences. There are two aspects to consider when discussing learning: (a) learning as an internal cognitive phenomenon, and (b) an activity as an object-oriented, outcome-directed, tool-mediated and external phenomenon. In simpler terms, cognition occurs in the head[2] and an activity occurs in the world, and the two are connected through consciousness (see Jonassen and Rohrer-Murphy 1999). In other words, thinking and doing together create context and experience for learning, therefore, a learning design must focus on what and how will learners' think, and what they will be doing in that context. Consciousness is metaphorically described as a plane where acts of thought take place (see Leont'ev 1978). Vygotsky (1962, 1978) made a distinction between natural psychological functions given to us by nature (e.g., memory, thinking, or imagination) and higher psychological functions, essentially socio-cultural in their origin (e.g. inner speech, formation of concepts, mathematical operations or theoretical thinking). For Vygotsky (1978), human cognitive activity is mediated by signs. A sign is an artificial, self-generated, second order stimulus that for Vygotsky, "transfers the psychological operation to higher and qualitatively new forms and permits humans, by the aid of extrinsic stimuli, to control their behavior from outside" (p. 40). The sign acts as a tool of a psychological activity and, for Vygotsky (1962, 1978), the use of tools and their subsequent interiorization, contribute to the development of higher psychological functions.[3] Interiorized signs mediate the higher psychological functions and, the use of external tools might lead to 'cognitive residue' or resources that can serve such purposes (that is, as a mediating sign). This interiorization is not cognitive mapping or copying of an external activity and tools; rather, it is achieved through the internal reconstruction of certain elements of external experiences into acts of thought. Higher psychological functions do not replace natural psychological functions, but are developed upon them, not as natural or biological, but as 'cultural extensions.' In Vygosky's terms, scientific evidence suggests that the human cognitive system has not changed biologically over the last few thousand years. So, how is it that today, we are smarter, able to develop machines and theories, create technologies and solve, for example, complex mathematical, medical, and engineering problems, in particular, rapidly since the beginning of the 20th century? The answer lies in the availability of conceptual tools that not just supplement our thinking and inner speech, but also our imagination and creativity.

Important
Use of tools and their subsequent interiorization, contribute to the development of higher psychological functions. Interiorized aspects of tools mediate

[2]There is also concepts of distributed cognition, which holds that thinking is distributed across the individuals and artifacts.

[3]Vygotsky (1978) emphasizes that psychological activity is not limited to use of tools and signs only—other issue, such as social interaction, play further roles.

the higher psychological functions, and might lead to 'cognitive residue' or resources that can serve such mediating purposes in further learning and activities.

We have already established that where cognitive resources are limited, external tools might mediate an activity, and make it possible for us to overcome our limitations in respect to the achievement of outcomes. This would allow individuals to perform tasks that are beyond their current developmental level, while internalization of these tools might potentially lead to a new 'zone of proximal development' being reached (Vygotsky 1978). However, this interiorization will occur only if tools are principally designed and used to serve this purpose. Thus, much attention in the author's work in this book is given to the design and use of concept representation resources as the most suitable form of digital resources for such learning purposes.

Representational technologies open a spectrum of opportunities, or affordances for design, development and the implementation of digital learning resources which can serve as mediating tools. Furthermore, as Salomon et al. (1991) suggest, technology tools offer the opportunities for individuals in partnerships that increases the overall intellectual capacity of this joint system (*a functional organ*). Technology is not only an extension to the body, but it is also an extension to the mind, that is, it is a tool that can extend the limits of our intellectual capacity. Kutti (1997) suggests that technology provides other supporting functions in an activity. These supporting functions "…are directed not towards manipulating or transforming the object but making the activity run" (p. 35). Technology might be used, for example, to automate some operations, make tools and procedures visible and comprehensible, explicate rules and the division of labour, connect a community in a network, and enable communication and collective actions.

7.5 Learning Design Model and Uses of Digital Resources for Learning

These theoretical foundations present important ideas for a difference to be made in the ways how digital resources for learning are designed and used in learning. Here is a summary of some of the key points, and synthesis of these in a concrete model or a framework for a learning design. In addition to a learning design and design of learning activities, this will also help us to better understand the design of digital resources for learning in a way that they support integration in learning experiences:

- Activity-theoretical perspective places an Activity at the centre of analysis in the articulation of a learning design;

- A teacher's role is to design an activity for learners to engage with when achieving an outcome.[4] The outcome of an activity from a teacher perspective is the achievement of a learning outcome(s). The outcome of an activity from a learner perspective is a physical, digital or a conceptual artefact to be produced for some meaningful purpose;
- The further role of a teacher is to identify and prescribe Resources (including digital resources for learning) which serve as mediating tools in an activity;
- The achievement of learning outcomes occurs incidentally in an activity, partly through resource mediation. Changes in the artefact (outcome of an activity) cause discourse, reflection and the reuse of resources, and these contribute to the achievement of learning outcomes as well;
- An activity might include group work (division of labour), collaboration (community), and framing parameters (rules). These are both, framing and supporting factors. In addition, other activities of learners (parallel activities) might have an impact on learning (e.g., learning activities in other subjects);
- The outcome of an activity, that is an artefact produced, should be evaluated by a learner, a teacher and/or community of participating learners (Evaluation). Feedback emerging from evaluation can provide a further mediating tool for learning. Furthermore, an important aspect of mediation can be achieved through the inclusion of supporting resources and strategies (Support). Support is required to ensure that learners are provided help, and where possible with strategies to independently, or in collaboration with other learners, effectively utilize resources and solve emerging difficulties, while Evaluation informs both learners and teachers about progress, and serves as a strategy for understanding what else needs to be done in order to ensure learning outcomes are achieved.

Based on these, four aspects of a learning design emerge as prominent: (a) an *Activity* that has an outcome; (b) *Resources*, or tools whose features when interiorized through a learning experience, in addition to the experience itself, change learners' knowledge; (c) *Support*, which might be essential for individual learners and communities during the implementation of a learning design; and (d) *Evaluation* of artefacts produced by learners in the activity, and timely provision of feedback and further ideas for its revision and improvement. Hence, our proposed model of a learning design contains four key elements: Resources, Activity, Support and Evaluation, and we call this learning design model the *RASE*. See Fig. 7.2 for visual representation and a summary of the RASE Learning Design model.

[4]This book does not argue that all teachers should produce digital resources for learning in their own. This job might be left to professional technology developers to accomplish. However, teachers might be the ones articulating what digital resources should be produced, and developing a blue prints or storyboards for implementation.

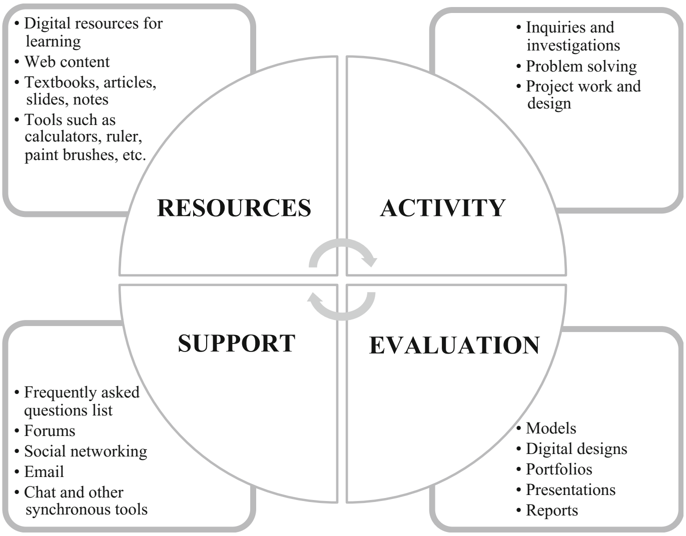


Fig. 7.2 The RASE learning design model

7.5.1 Resources

Resources include (a) content resources (e.g., digital resources for learning, textbooks, lecture presentations), (b) material (e.g., chemicals for an experiment, paint and canvas), and (c) instruments and software that learners use when working on their activity (e.g., laboratory tools, brushes, calculators, rulers, statistical analysis software, word processing software). In addition to digital resources for learning, there are various software tools that learners can use in an activity, e.g., a Mind Mapping tool such as MindMeister, image/video editing tool such as iMovie, professional software such as AutoCAD and Mathematica, and model building and experimentation software such as Interactive Physics and Stella. When integrating digital resources in learning design, it should be done in a way that leads learners to learn with, rather than just learn from these resources. Digital resources are mediating tools in an activity, they are not representations to be copied in someone's mind in original format. Rather, tool using experience leads to interiorization that is a reconstruction of the tool-using experience in one's cognition. Since the main purpose of this book is to examine digital resources for learning, we will shift our attention in the remainder of this chapter to other elements of the RASE.

7.5.2 Learning Activity

In general, when we talk about an activity, we are thinking of various kinds of inquiries, problems and projects for learners to work on. An activity provides a focus for learners to engage in an outcome-directed set of actions. Learning emerges as a part of the process of adaptability to the conditions of the activity, that is, learning is voluntary and directed as an applied strategy towards achieving a particular outcome. An activity provides learners with a context and an experience where learning occurs through tool mediation, collaboration exploration, reflection, testing and understanding emerging ideas, generalizing, abstracting and applying knowledge. Digital resources for learning, such as conceptual representation resources, are mediating tools that a learner uses while completing their activity.

For Jonassen (2000), learning is most effective when it occurs in the context of an activity that engages learners to solve ill-structured, authentic, complex and dynamic problems. These types of problems differ significantly from logical, well-structured problems with a single solution (including logical problems, algorithmic problems, story problems, and rule-using problems). These ill-structured types of problems include: decision making, case study, troubleshooting, diagnosis solution problems, strategic performance tasks, design tasks, and dilemmas, all of which require learners to engage in deep thinking, examination of multiple possibilities, deployment of multiple theoretical perspectives, uses of tools, creation of artefacts, and exploration of possible solutions. Churchill and Hedberg (2008) classify Jonassen's problem types into four categories including application of rules, incidents-based decision making, strategic solution and role taking (see Table 7.1).

Understanding how different types of digital resources for learning support different types of activities can provide useful heuristics for selecting digital resources from repositories and the Internet more generally. In addition, the framework might also be useful for the designers of digital resources in suggesting ones that might be useful to develop. Table 7.2 links different types of digital resources for learning to different types of problems.

Table 7.1 Types of problem activities and their focus (from Churchill and Hedberg 2008)

	Rule-based	Incident-based	Strategy-based	Role-based
Description of the category	Explicate, practice and apply standard procedures and rules in the solution. Learners meaningfully and reflectively apply procedures and processes	Exposure and participation in authentic and realistic events or incidents. The activity require learners to reflect and take decisions based on their responses to events	Explore the strategies employed to achieve goals. Often the strategy options are generated as part of the solution	Participate as a player and participant in a setting that models a real world issue. Learners negotiate, apply judgments experience subrogation and employ multiple perspectives
Type of problem under the category (based on Jonassen 2000)	Logical problems Algorithmic problems Story problems Rule-using problems	Decision making Case study	Troubleshooting Diagnosis solution problems Strategic performance tasks Design tasks	Dilemmas

Table 7.2 Different types of problems and digital resources for learning

Type of LO	Type of an activity			
	Rule-based	Incident-based	Strategy-based	Role-based
Presentation resource	Instruction how to execute certain algorithm (e.g., calculate area of a triangle)[a]	Presentation slides instructing issues to consider when making a decision in relation to an event or incident (e.g., what to do if a driver refuses to produce his or her license)	Description of the strategy and procedure to be used in solving a problem (e.g., how to troubleshoot a faulty computer)	Instruction how to act in a situation requiring an answer to a controversial question (e.g., what to do if a learner with special needs fails to submit an assignment)
Practice resource	A practice resource that allows a learner to repeatedly practice the application of a rule (e.g., calculate circumference of a circle with given diameter)	Practice requiring action based on an emerging event or incident (e.g., select a medication for a patient based on symptoms presented)	Practice that allows a learner to dismantle and assemble a certain system and explore its components (e.g., dismantling and assembling a water pump)	Practice that requires a learner to interact with a virtual character and negotiate a solution (e.g., negotiating court case settlement)
Conceptual representation resource	A representation that enables a learner to construct internal model of a rule to be used in the solution of an algorithmic problem (e.g., representation of how to divide two numbers)	A representation that allows a learner to explore if-than or cause-and-effect scenario (e.g., effect of the spread of birth flu on markets in Asia)	A representation of a concept which guides an expert in diagnosing a problem and proposing solution (e.g., concept of Ohm's Law)	A representation of value system held by an expert that supports his or her judgment (e.g., value system of a movie producer who produced a controversial film)
Information display resource	An illustrated story problem (e.g., James has to go to the airport to meet his father. How long it would take him to get there based on given parameters)	An interactive table of some useful information or a flow graph of decision-making process (e.g., trigonometric table)	Information with a list and description of items (e.g., items required for the interior design of an apartment)	An organized collection of articles (e.g., newspaper clips allowing a learner to explore them, for example, by navigating along a time)

(continued)

Table 7.2 (continued)

Type of LO	Type of an activity			
	Rule-based	Incident-based	Strategy-based	Role-based
Data display resource	A simple real-life scenario that provides few variables that can be captured and used in the rule to solve a problem (e.g., click on a vehicle to capture how fast it is going)	A realistic scenario that provides data that are used to make a decision (e.g., collecting water quality indicators form the lake)	A representation that allows the collection of data from a realistic scenario that shapes the strategy applied in solving a problem (e.g., collecting performance data from a faulty engine)	A scenario that allows a learner to collect the views of different people affected by the situation (e.g., collecting views about the war in Iraq)

[a]These are suggested rather than absolute possibilities

Activity 7.1
The following table displays a list of examples of activities. Complete the rest of this table by describing possible digital resources for learning that can be used to mediate each of the activities listed. You can recommend multiple resources, however, for each of the activities, provide at least one description of an example. If possible, search the Internet and various repositories of digital resources and provide links to those that might be appropriate to mediate these activities.

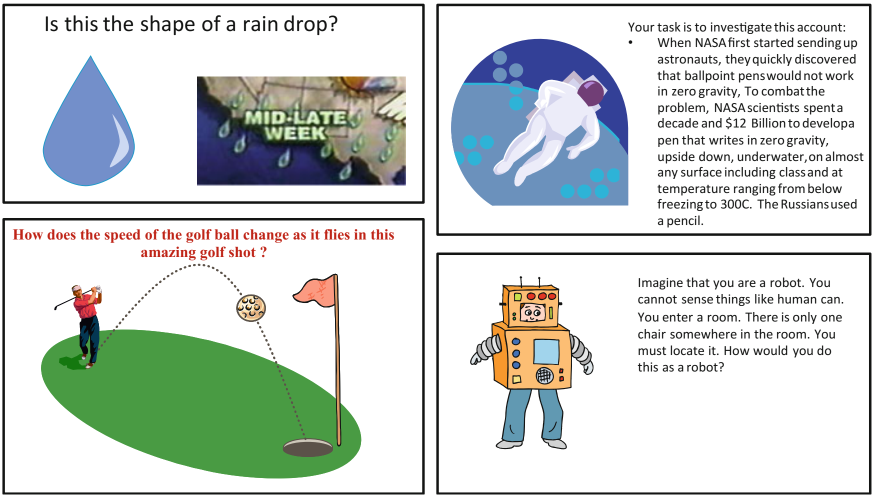


Fig. 7.3 Examples of problem questions

Fig. 7.4 An activity and resources introduced with the aid of a presentation (note slide 6 which provides links to digital resources for learning on three different topics)

Example of an activity	*Proposed digital resources for learning*
A design project (e.g., design an experiment to test scientific hypothesis)	
Case study (e.g., a case of how a scientist identified a new physics regularity)	
A problem solving learning task (e.g., minimizing friction in the design of a ski)	
Develop a documentary movie on a specific issue of interest (e.g., GM food pros and cons)	
A poster to promote a controversial scientific issue (e.g., Nuclear energy)	
Planning a science day in your school	
Develop software to control the mechanical transfer of power	
Role-play (e.g., defending the right to conduct science experiments with small animals)	
Create an aerial map of an area surrounding and including the school	
Develop a digital story to promote an artistic creation	
Write a proposal for suitable water treatment technology to overcome a water shortage problem	
Plan a menu for foreign visitors	
Design a model to demonstrate how friction plays an important role in motion	
Create a visual representation (e.g. mind map) that illustrates the rise and fall of Napoleon Bonaparte	
Maintain a blog that describes the benefits of living in a particular country	
Develop a presentation about 21st-century artefacts that will no longer be useful in the Year 3000	
Collect and organize material to support an argument for or against Brexit	

An activity might be simply presented and triggered, as in the examples of problems/inquiries in Fig. 7.3. Further scaffolding/supporting a structure can then be provided to direct learners further (e.g., templates, rubrics and recommended resources).

Alternatively, an activity might be presented as an interesting scenario through the display of a problem or a project with the aid of multimedia to initiate interest, display clear instructions to follow and provide links to resources (see Fig. 7.4).

Activity 7.2

Select one of the examples of the activities presented in Activity 7.1. Now, look at the example of a presentation of an activity illustrated in Fig. 7.4. *For your selected example of an activity from Activity 7.1, describe a scenario* *you would recommend to introduce the activity to students and provide links to the resources and supporting templates for completion of the required work. You might use PowerPoint or other tools to develop slides to introduce the activity.*

7.5.3 Support

The purpose of support is to provide learners with essential scaffolding while enabling the development of learning skills and independence. For teachers, one aim is to reduce redundancy and workload. Support might anticipate a learners' difficulty, such as understanding an activity, using tools or working in groups. In addition, teachers must track and record ongoing difficulties and issues that need to be addressed during learning, and share these with learners. Three modes of support are possible: teacher-learner, learner-learner, and learner-resources. Support can take place in a classroom and in-online environments such as through forums, Wikis, Blogs and social networking spaces.

Support can be seen as anticipatory based on foreseen learners' needs or something unforeseen that emerges through learning. Depending on the course, support structures such as FAQs can be planned and implemented in light of anticipated needs. The objective of anticipatory support is to ensure learners have access to a body of resources when they need help, rather than being dependent on asking teachers for help. Here are some specific strategies:

- Build content and materials which form a FAQ Page;
- Create a "How Do I?" or "Help Me" Forum;
- Create a Glossary of course-related terms;
- Use checklists and rubrics for activities; and
- Use other social networking platforms and synchronous tools such as chat.

Overall, support should aim to lead learners to become more independent. Teachers should give frequent, early, positive feedback that supports learners' beliefs that they can do well. Furthermore, learners also need rules and parameters for their work. For example, before learners can ask a teacher for help, they must first ask their classmates through a forum and/or search the Internet for solutions to their problem(s). In this way, learners are expected to take responsibility for their learning and to support other learners in their groups.

7.5.4 Evaluation

An activity should require learners to work on tasks, and develop and produce artefacts that evidence their learning. Outcomes of an activity can be a conceptual artefact (e.g., an idea or a concept presented in a written report), a hard artefact (e.g., a model of an electric circuit), or a soft artefact (e.g., a multimedia report). Artefacts produced by learners should undergo peer and expert review and revision before final submission. This process may also involve learners' presentations and peer/expert feedback. The produced artefacts should be evaluated in a way that learners can reflect upon feedback and take further action towards a more coherent achievement of the learning outcomes.

Evaluation of learning during the semester is an essential part of effective learning-centered teaching practice. Evaluation needs to be formative in order to enable learners to constantly improve their learning. This evidence of learner learning enables the teacher to monitor progress and provide further formative guides to help improve learning achievements. Learners also need to record their progress in completing the tasks set, so they too can monitor their learning and the improvements they make. Rubrics can be provided to enable learners to conduct self-evaluation as well. Rubrics might, for example, play an important role in the learning process to orientate learners to the standards that need to be achieved in their work.

Activity 7.3
Select one of the digital resources for learning you developed previously through the chapters (e.g., atmosphere, protractor or season changes). Propose a learning activity for learners to make use of that digital resource in learning.

7.6 An Example of Digital Resource for Learning Used Within an Activity

A group of school learners were presented with a problem requiring them to identify the height of objects in their school environment, such as, school buildings, lampposts and trees. This challenge was part of a larger cross-curriculum activity that involved learners in designing a small-scale model of their school (which subsequently used it as a miniature set for their digital video projects). The learners worked in small teams and obtained measurements of different objects in their environment in order to construct a model to an appropriate scale. Although they were able to simply use a tape measure to measure parameters, this was not possible with vertical objects such as trees, lampposts and buildings. Divided into small groups, they were given a tape measure to measure the distance from a group member to the object (e.g., a tree) and an inclinometer to measure the angle of elevation from the horizontal plane at a group member's position to the top of an object (see Fig. 7.5). The groups were also provided with a mobile device equipped with a camera feature to collect evidence of their data collection, which they needed for the subsequent presentation of their solutions and approaches.

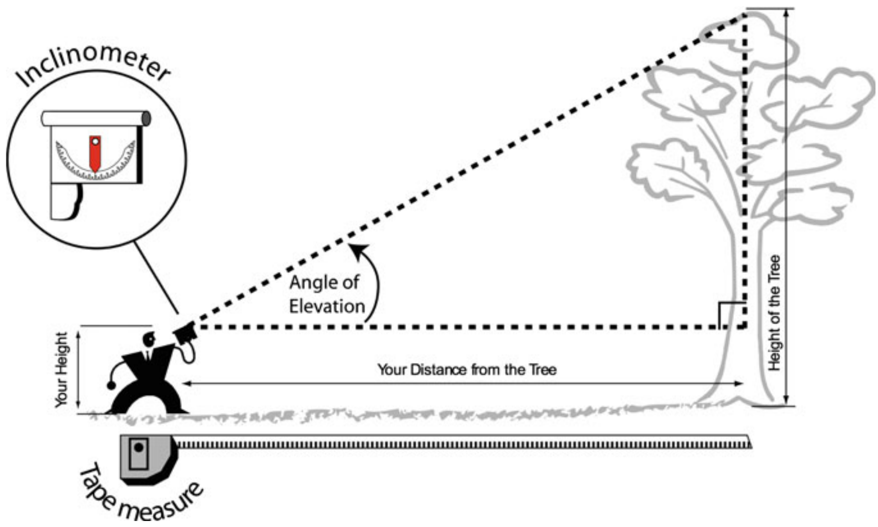


Fig. 7.5 Collection of measurements required to solve the problem

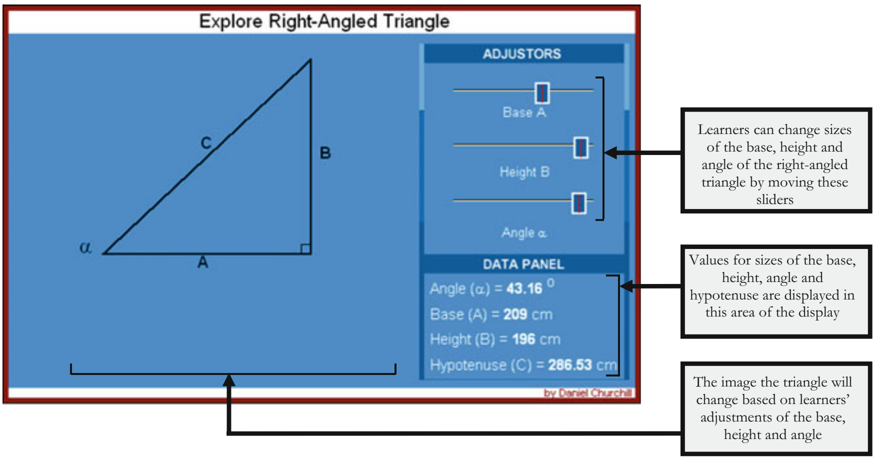


Fig. 7.6 "Exploring right-angled triangle" digital resource for learning

A digital resource for learning used in this project is presented in Fig. 7.6. This digital resource for learning is a conceptual representation called "Explore Right-angled Triangle". This resource could possibly be used in a variety learning activities enabling learners to develop mathematical concepts such as Pythagorean Theorem, similar triangles, trigonometric rules and the rules for calculating missing parameters.

The learners manipulate the values for the base, height and an angle of a triangle, and then examine changes in the value of the hypotenuse by repositioning a set of corresponding sliders. This allows learners to keep the angle constant while changing the sides of the triangle and examining the ratio that exists between the sides. The changes are represented:

- Numerically as numbers relating to the sides and angles of the triangle; and
- Visually as a dynamic drawing of a triangle.

The learners were provided, amongst other resources, with this digital resource for learning. Prior to going into the field, the learners explored this resource via a computer screen. They were told that it would later be helpful during their fieldwork. Their initial exploration of the content was supported by a set of questions and graphical organizers (templates) which directed them to approach this exploration in a systematic way: e.g., to collect some values in a template table, to compare different rows and columns in search of patterns, and build some preliminary generalizations about the concepts represented by the resource. Once the learners moved outside of the classroom to collect the measurements of the objects, some mobile devices with the resources were made available for them to use as a reference tool while they interpreted the situation and explored possible solutions. The solution to the problem of finding heights of tall objects is based on the ratio of the base and height of a triangle that remains constant for any size of right-angled triangle with the same angle of elevation. Groups of learners were encouraged to discuss and share their problem-solving approaches. Once the groups arrived at their solutions, a representative of each group was required to present their solution to the rest of the class. The presentation contained a proposed solution to the problem of calculating the height of tall objects, an approach to the solution was based on the conceptual representation resource and digital photos they collected with the mobile device of the objects that they measured.

Several weeks later, the learners were asked to estimate the values of a ratio of the sides of a right-angled triangle with given sizes of an angle provided to them. They were also asked to recall their experience with the resource used and to explore whether this recall would help them in their estimation. Interesting patterns were observed as the learners begun to employ auxiliary means to help them in this estimation. Some learners sketched triangles on paper. Others used their pens, rulers and other objects as arms of a constructed angle. Some learners used their fingers as arms of an angle in attempting to reconstruct elements of the digital resource in the air in front of their eyes. These behaviours indicated that some form of interaction between mental structures (cognitive residues from the previous activity and interaction with the content of the resource) and physical objects (auxiliary means) were occurring. Aspects of an activity involving the resource were reconstructed as a cognitive resource in a similar way to the way children learn to work with numbers. Vygotsky (1962) observed that when learning to count or perform simple addition or subtraction, young children are likely to use their own fingers as auxiliary means. Children will later begin to hide their hands behind their backs and keep using their fingers to aid the process; the auxiliary means disappears from the visual field but remains physically present. Slowly, children will stop using their fingers, or other auxiliary means and the process will become more internal. Auxiliary means do not disappear, however, through the internalization of an external activity, they begin to operate purely in the mind, that is, they take the form of an internal tool for support of their theoretical thinking.

In the remaining part of this project, learners were constructing their miniature set based on a specified scale. Finally, they were to use their models to construct a short Play-Doh[5] animation. It was observed that some learners frequently accessed the digital resource during the process of construction. In some way, the resource became a useful calculator and a conceptual supplement to learners in this context.

Activity 7.4
By this stage you should be ready to design a complete learning design plan. The following template will assist you in completing such a task and delivering your learning design for implementation via *a digital or other environments. Complete the form for a selected learning unit of your choice. Pay attention to important concepts covered in this Chapter, and reflect on these in the 'Theoretical Perspectives' part of this form.*

Learning Design Planning
(Based on the RASE framework)

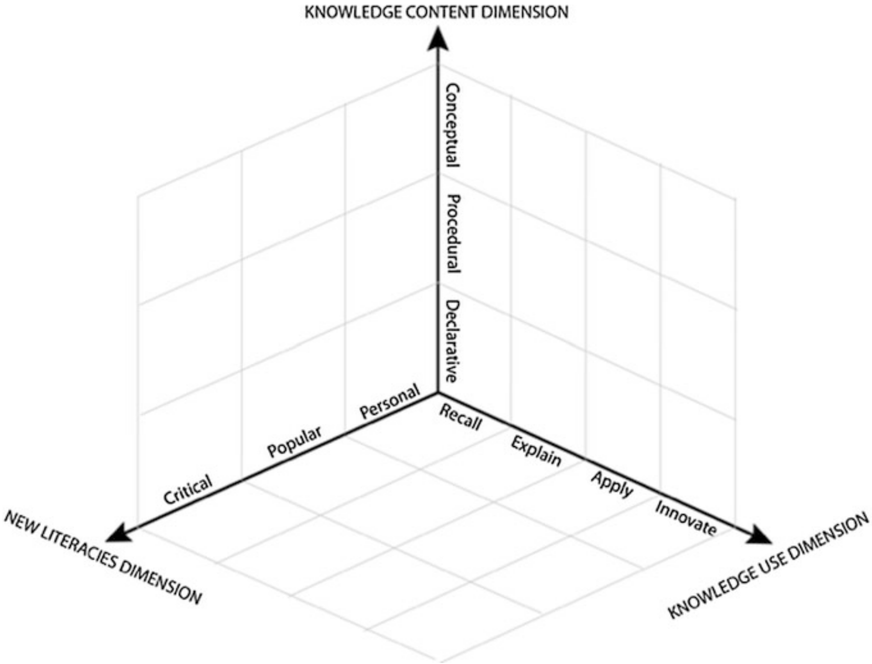
Topic of a Learning Unit:

Learning Outcomes:
Specify learning outcomes (maximum 3)

1. 2. 3.

[5]Play-Doh, also called plasteline or plasteline clay, is a soft modeling material used by children to build models, structures and art work. See the official Play-Doh site for more information http://playdoh.hasbro.com/

Plot the learning outcomes in the graph below:



Activity:
Describe an activity for learners to achieve the learning outcome(s).
Describe what learners will deliver at the end of their activity.
Describe a scenario you will present to introduce the activity.

Resources:
List resources learners will use in the activity (include some digital resources for learning).

Support:
How learner learning be supported, develop any template to scaffold their work for the activity, list any additional resources to be used in case learners need further assistance, etc.

Evaluation:
How will you evaluate learners' artefacts developed in the activity? Develop a list of criteria for satisfactory completion of the activity (you can try using http://rubistar.4teachers.org/index.php to develop a rubric for this purpose).

Develop an e-learning environment to implement your learning design
You have several options to do this:

- Develop it inside of a learning management space or other system (e.g., Moodle, Course Sites, iTunesU, Canvas, Scholastic, EdModo, Facebook);
- Develop it as a web site (e.g., Google Sites);
- Develop it as a blog or wiki (e.g., Blogger, Wikispaces);
- Develop it as WebQuest;

- Develop it with a presentation tool such as PowerPoint; or
- Develop it as e-book with iBookAuthor.

My learning design is available for viewing at:

Theoretical Perspective:

The last part of your activity is to write a short paragraph to describe how important the theoretical concepts introduced in this chapter are in underlining your learning design, that is, how you think learning will occur.

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